Redshift Identification Study:
Effects of Line Flux and Resolution

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Outline

- Principal Component Analysis z-finding method
- Simulation Results
  - Line flux effects
  - Spectrograph resolution effects

Principal Component Analysis

- Most basic level:
  - Observed Spectrum = Σ [(Coefficient)$_i$ $\times$ (Template)$_i$]

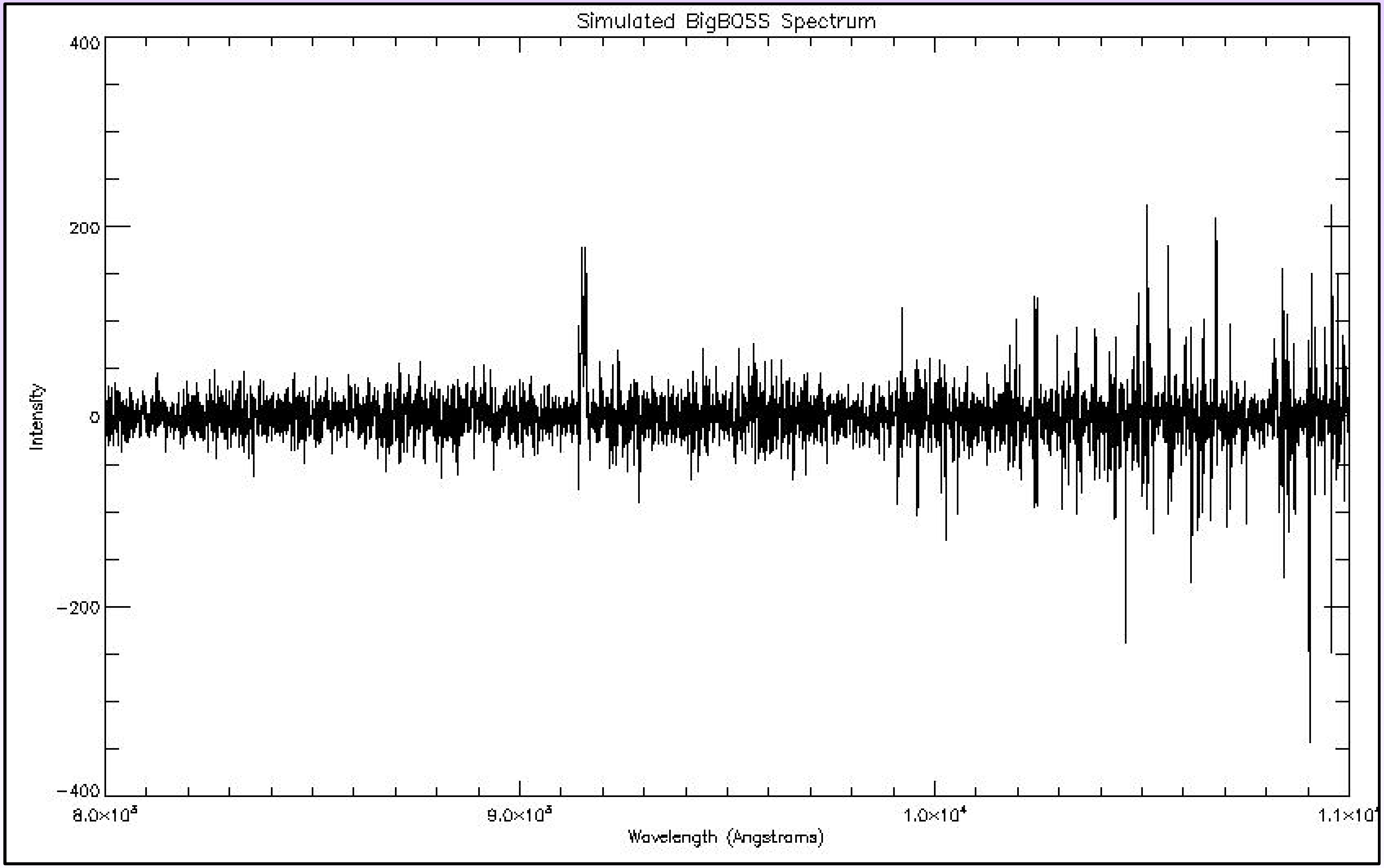
- Reduced χ^2 problem
  - Find the coefficients that minimize:

$$\chi^2 = \frac{[\Sigma\ (\text{Coefficient})_i \times (\text{Template})_i - (\text{Observed Spectrum})]^2}{(\text{Observed Spectrum})}$$

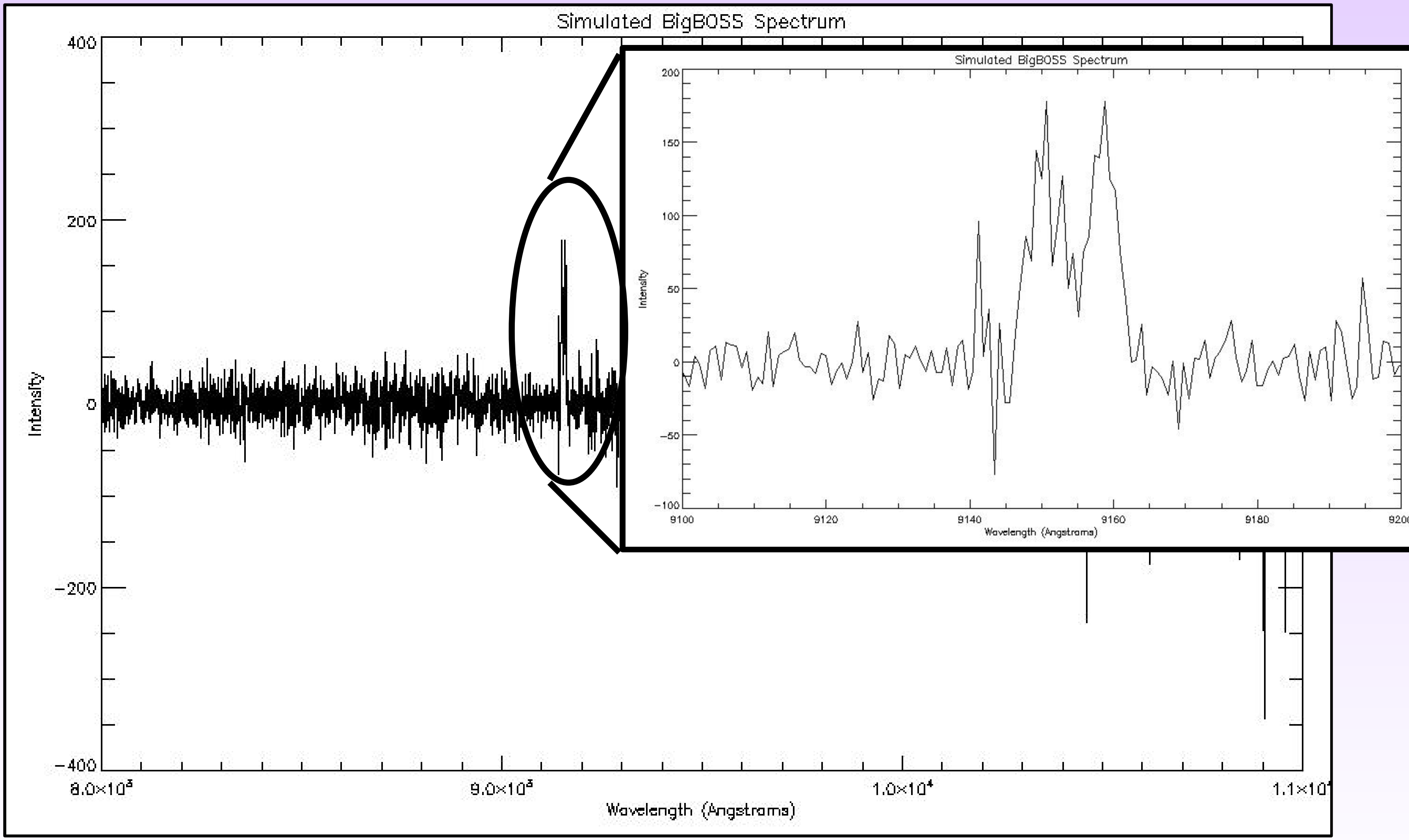
Emission Line Spectra Fitting

- Templates = Spectral Lines
  - Perform multiple fits with many sets of templates, each with unique z and σ (velocity dispersion)
- Interested not so much in template coefficients, but which (z,σ) pair produces lowest χ^2
- Use individual templates for each line
  - OII, OIII, Hβ
  - No assumptions about line flux ratios

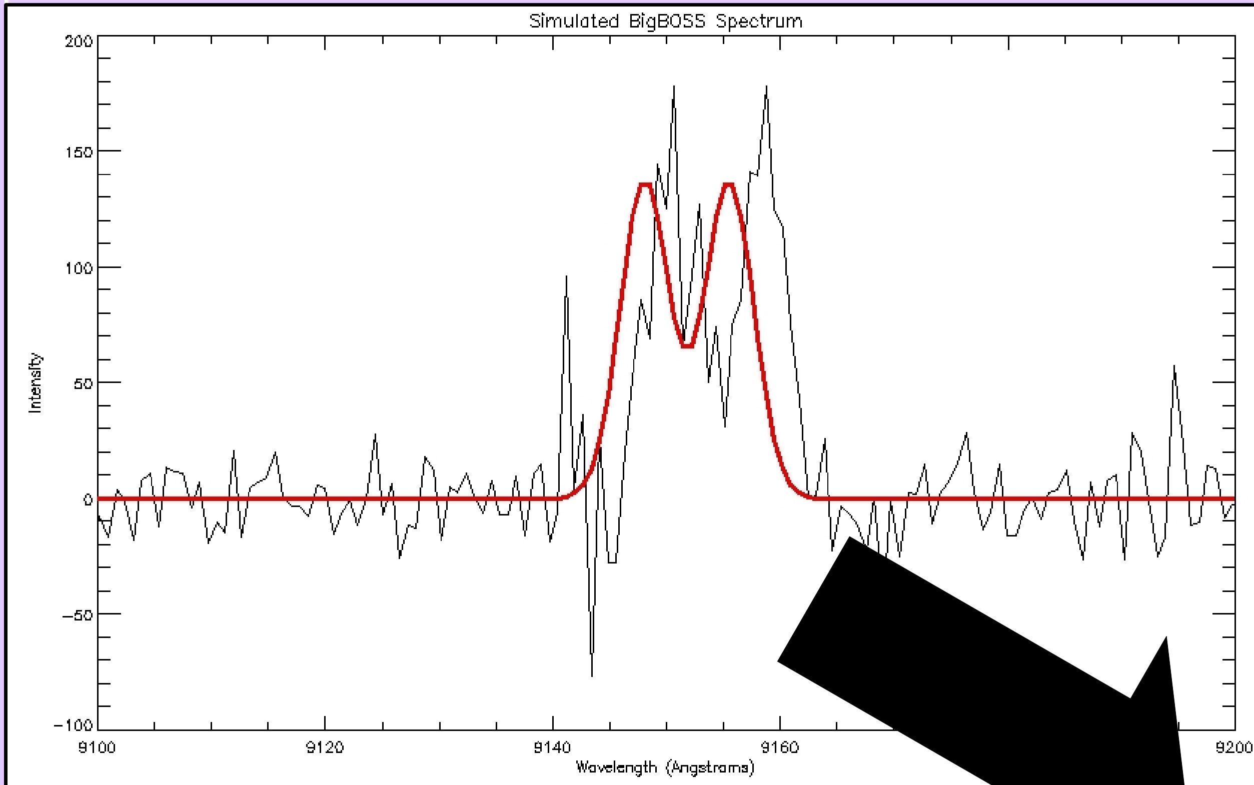
Example: z = 1.45537



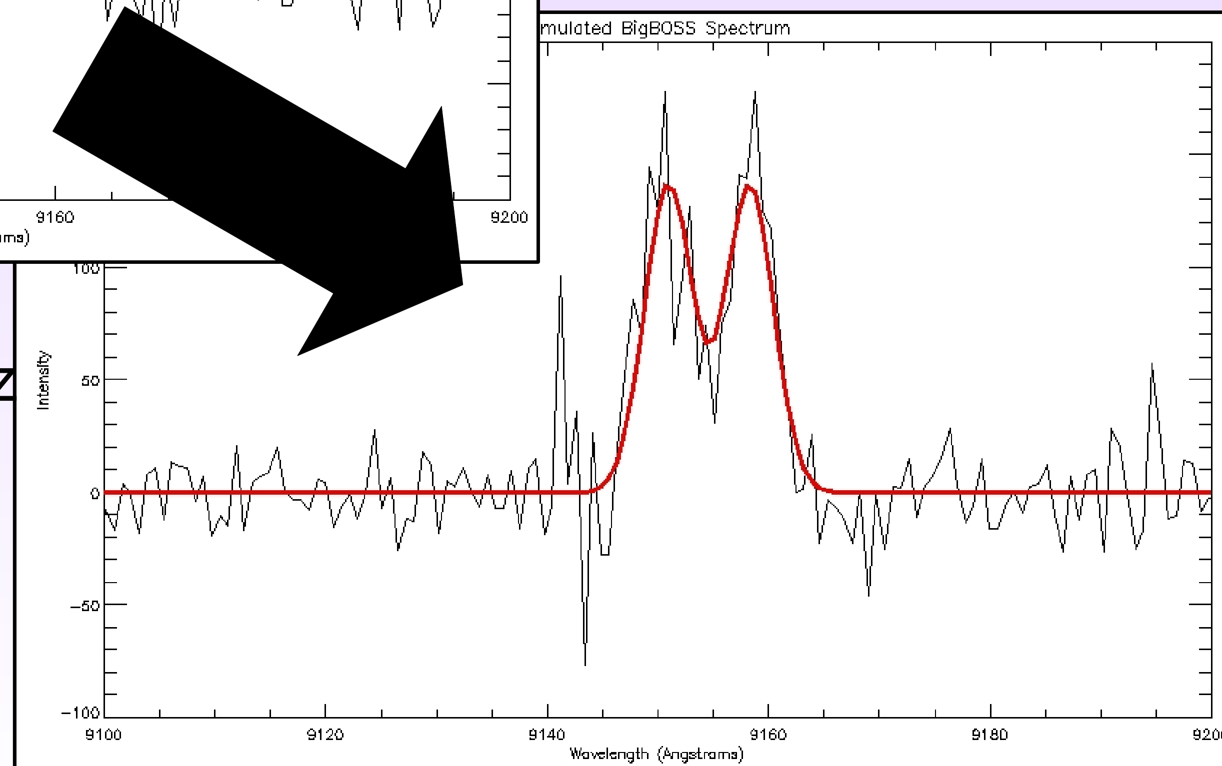
OII Doublet at 9151Å



Template Fitting: Overview



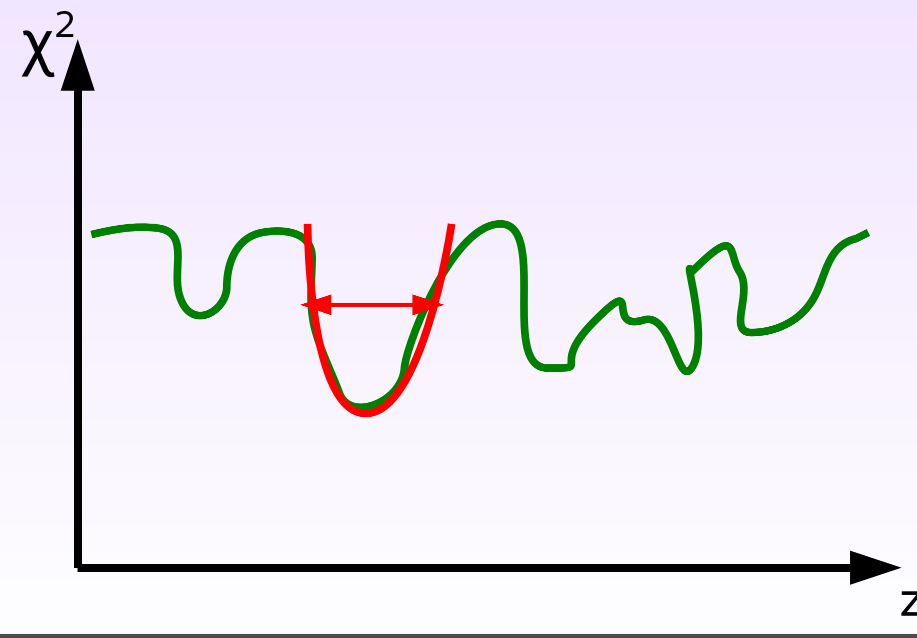
Red curve =
OII Doublet Template



- Cycle through templates of various z
- Simultaneously cycle through σ
- Fit for χ^2 at each (z,σ) pairing

Template Fitting: Details

- Template z's range from 0.7 to 2.0
  - Steps of 6×10^{-5} (~15 km/s)
- Template σ's range from 10.0 to 150.0 km/s
  - Steps of 1 km/s
- Look for minimum χ^2 in z-σ plane
  - Fit Gaussian to minima
  - Width of Gaussian gives estimate of uncertainty in z, σ
    - Typical σ_z: $< 10^{-4}$
    - Typical σ_σ: 10 km/s

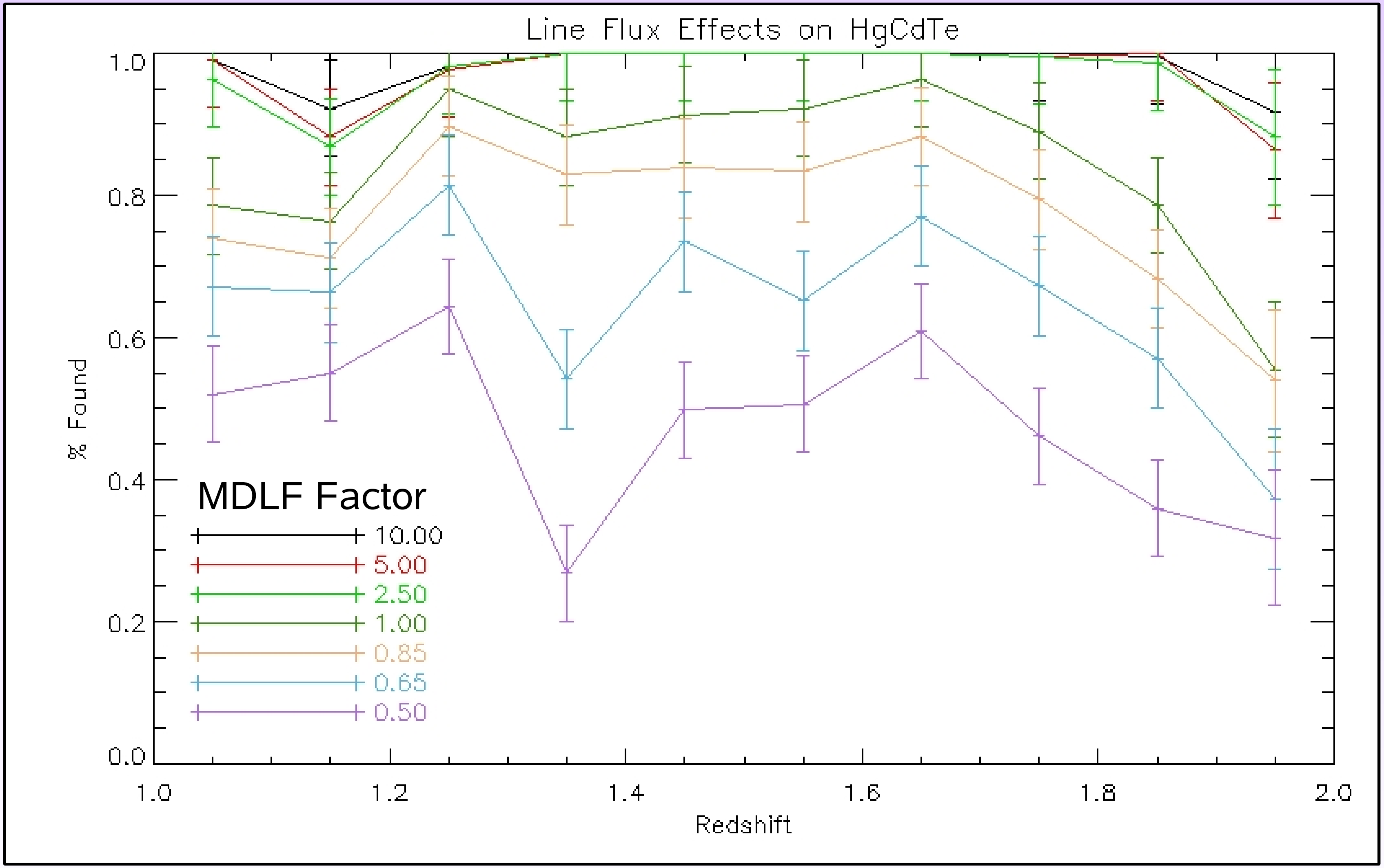


Simulation Results: Line Flux Effects

Line Fluxes

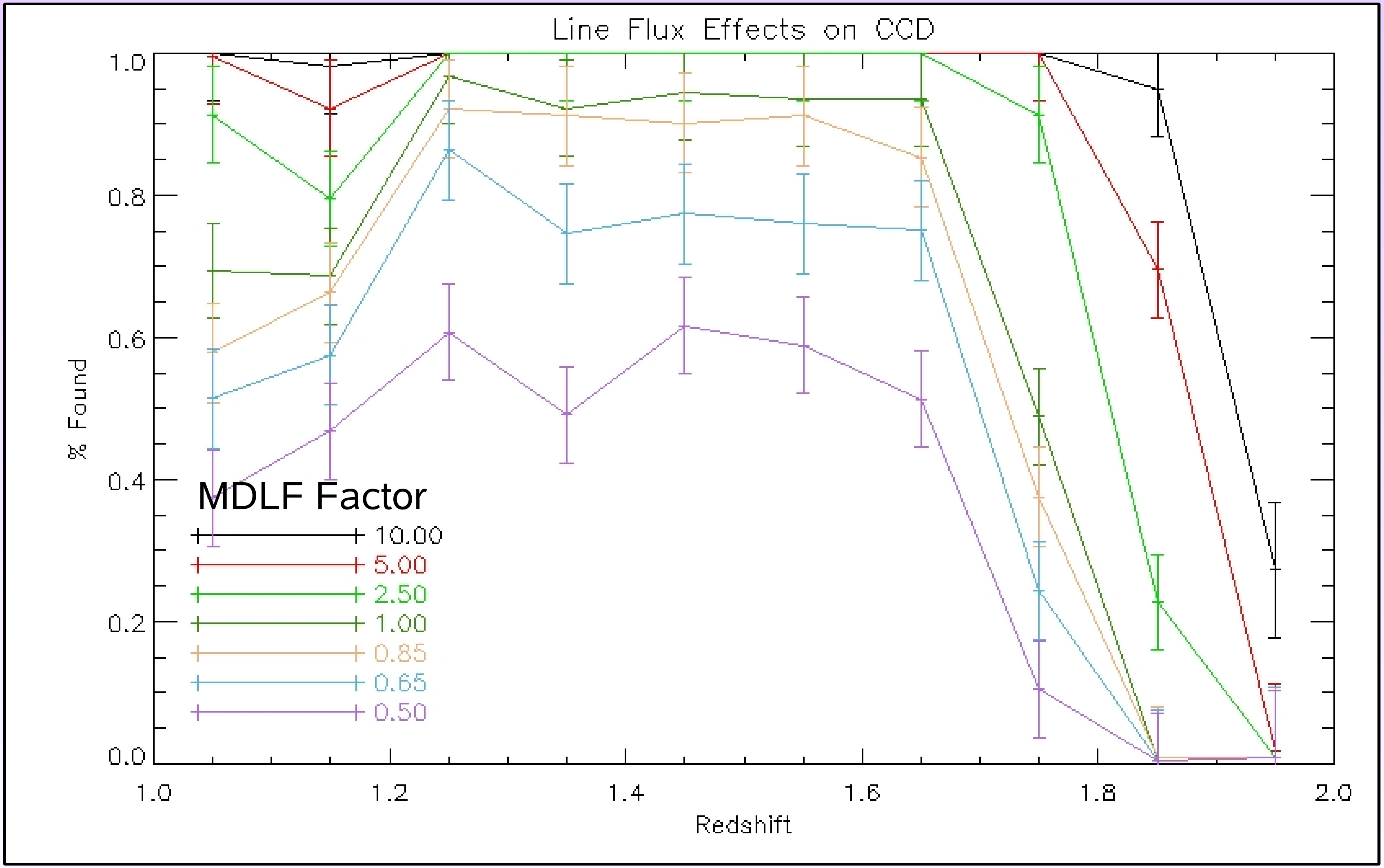
- Minimum Detectable Line Flux (MDLF)
  - MDLF = 2.5×10^{-17} ergs s^{-1} cm^{-2}
- Simulate sets of 2000+ spectra where line flux is constrained to be a multiple of the MDLF
- Look at z-finding success rate for simulated response of both CCD and HgCdTe detector

HgCdTe Results



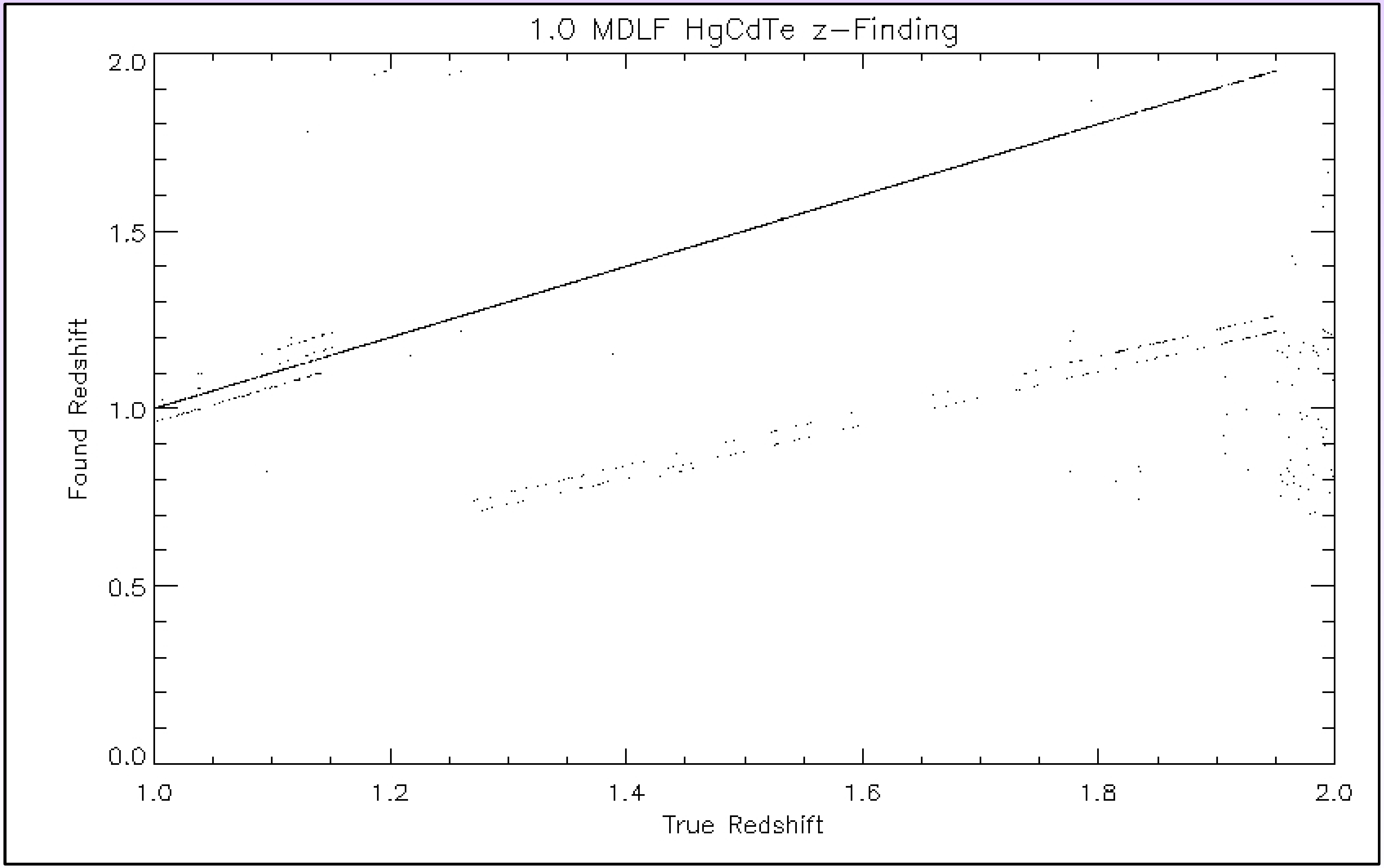
Note: error bars are simply Poisson scatter based on the number of objects in each bin

CCD Results

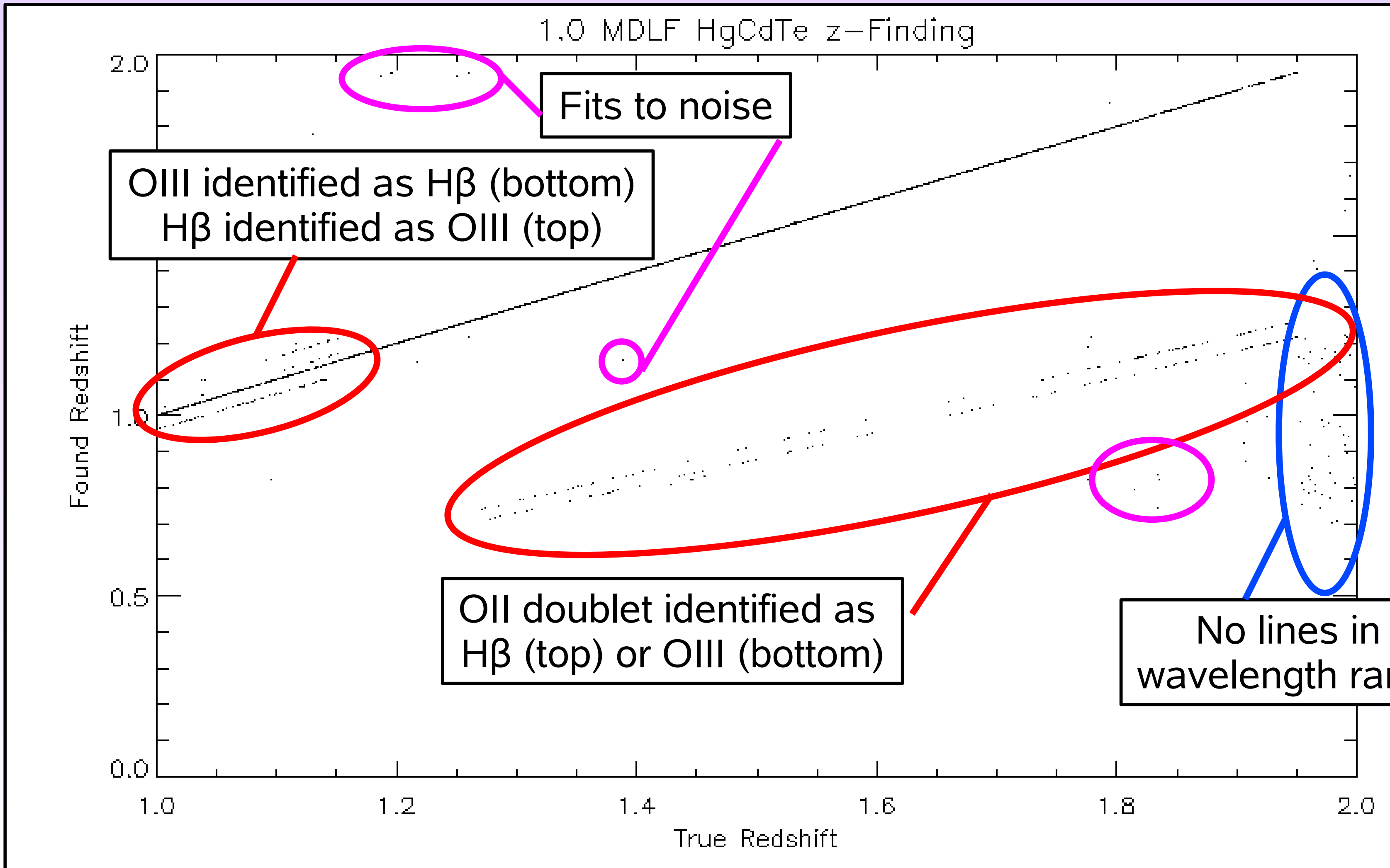


Line Flux Effects on CCD
% Found
Redshift
1.0
0.8
0.6
0.4
0.2
0.0
1.0
1.2
1.4
1.6
1.8
2.0
MDLF Factor
10.00
5.00
2.50
1.00
0.85
0.65
0.50

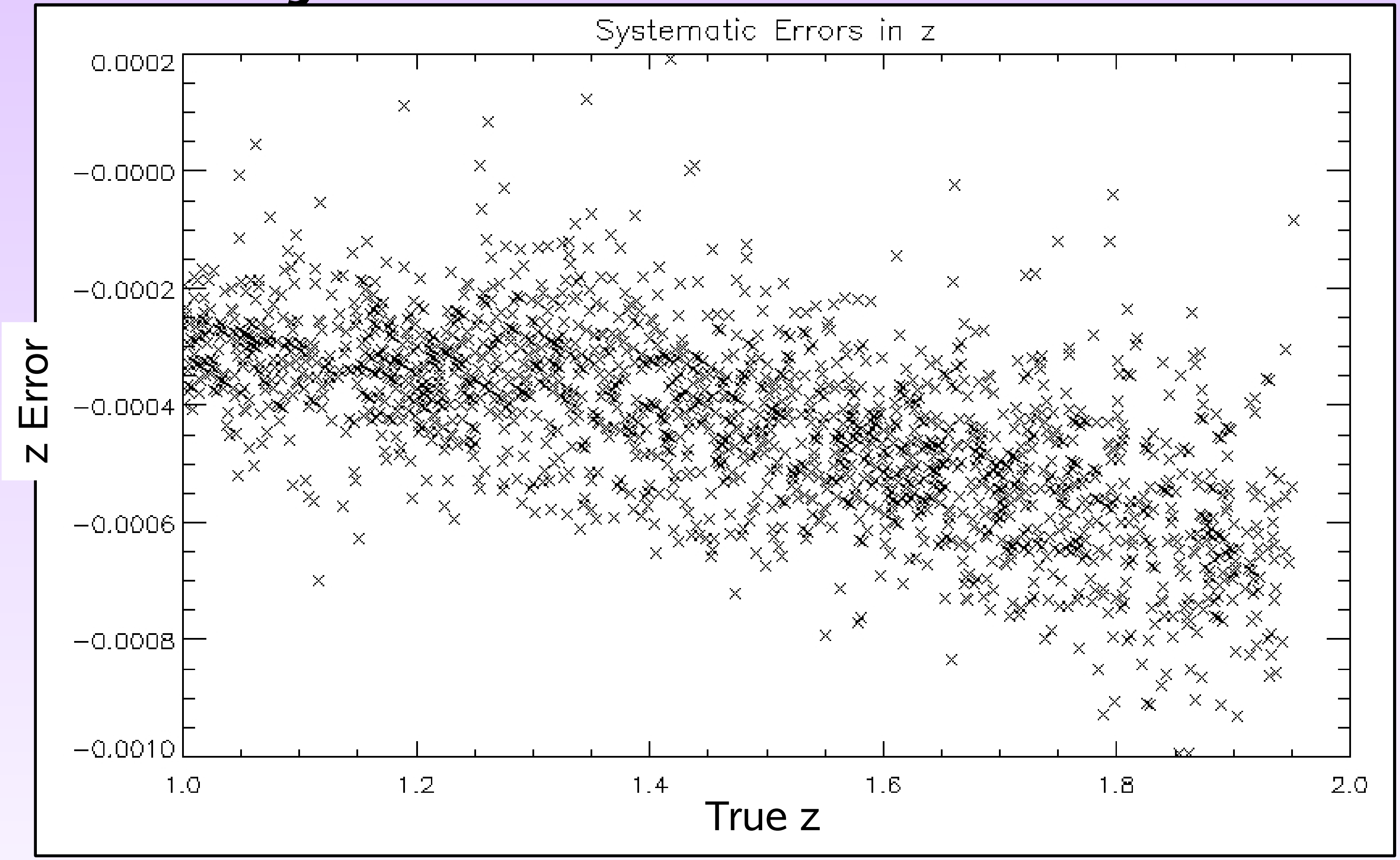
Individual Case: HgCdTe 1.0 MDLF



What Causes Misfits?

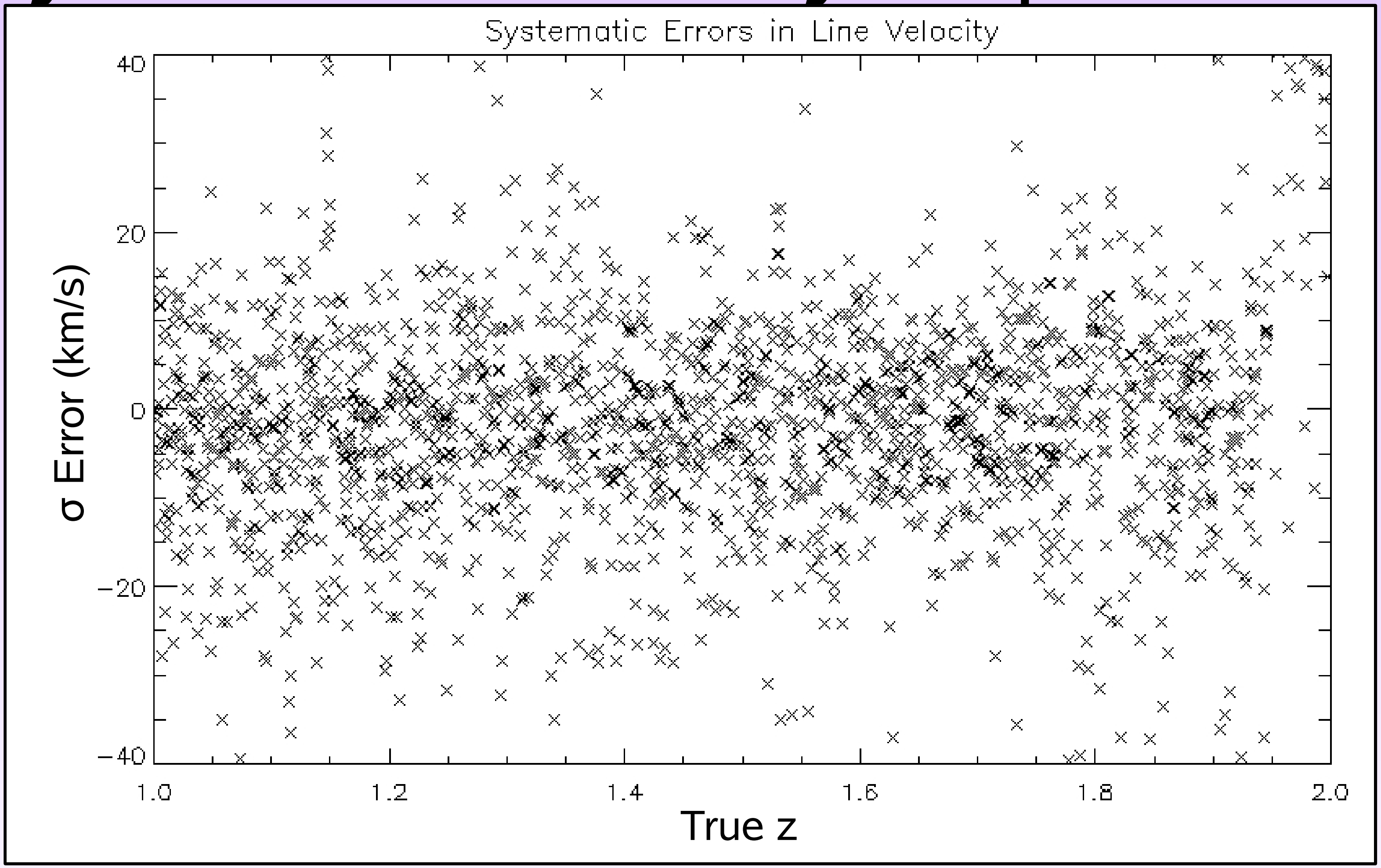


Systematics: Redshifts



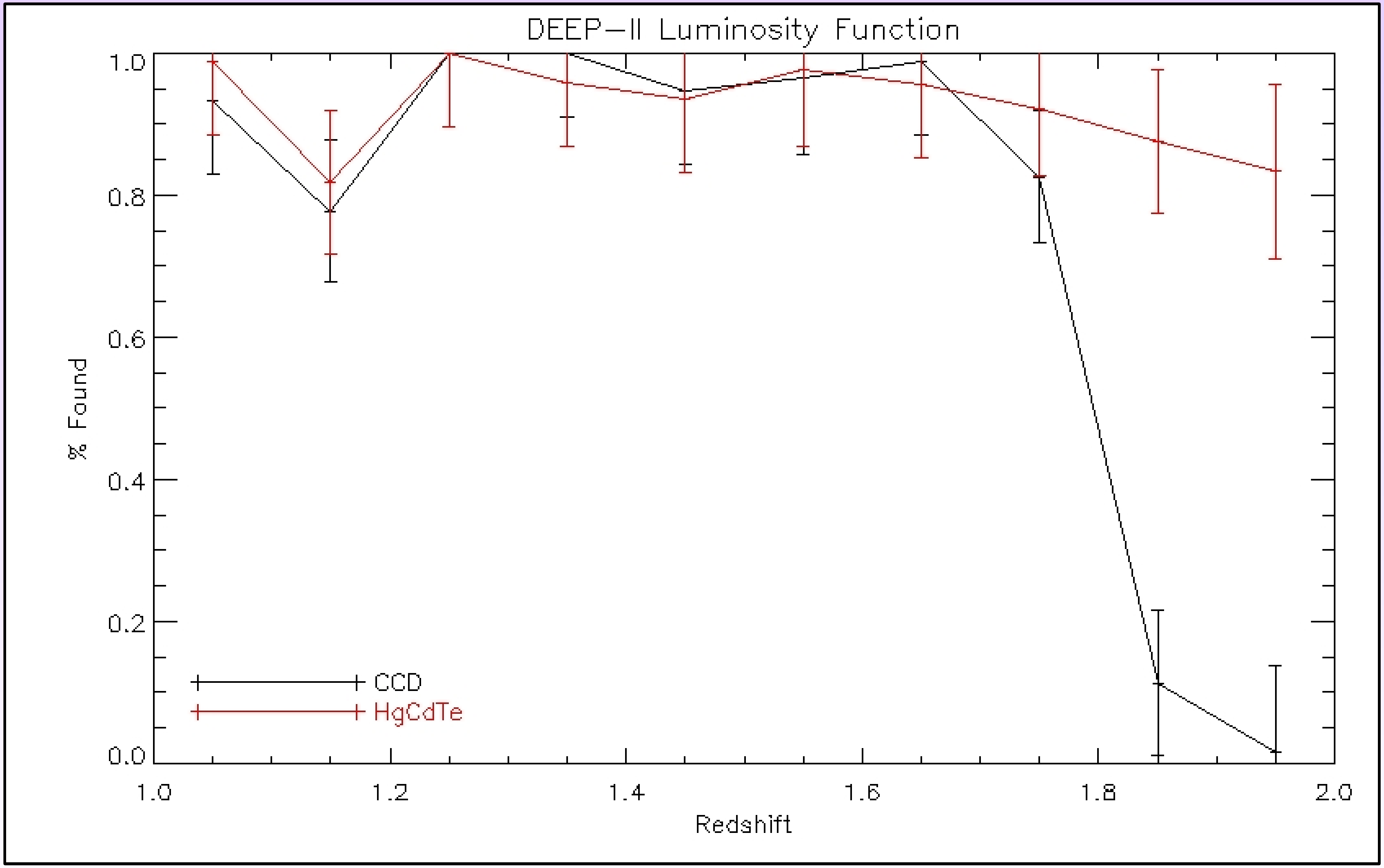
- ~ 2 × 10^{-4} offset between true z and recovered z
  - Discrepancy between code for spectrum simulation and templates
- ~ 5 × 10^{-4} biasing with higher z
  - Attributable to the same error?

Systematics: Velocity Dispersions



- Large scatter in σ, but values not crazy
- No obvious biases

DEEP-II Luminosity Function Results

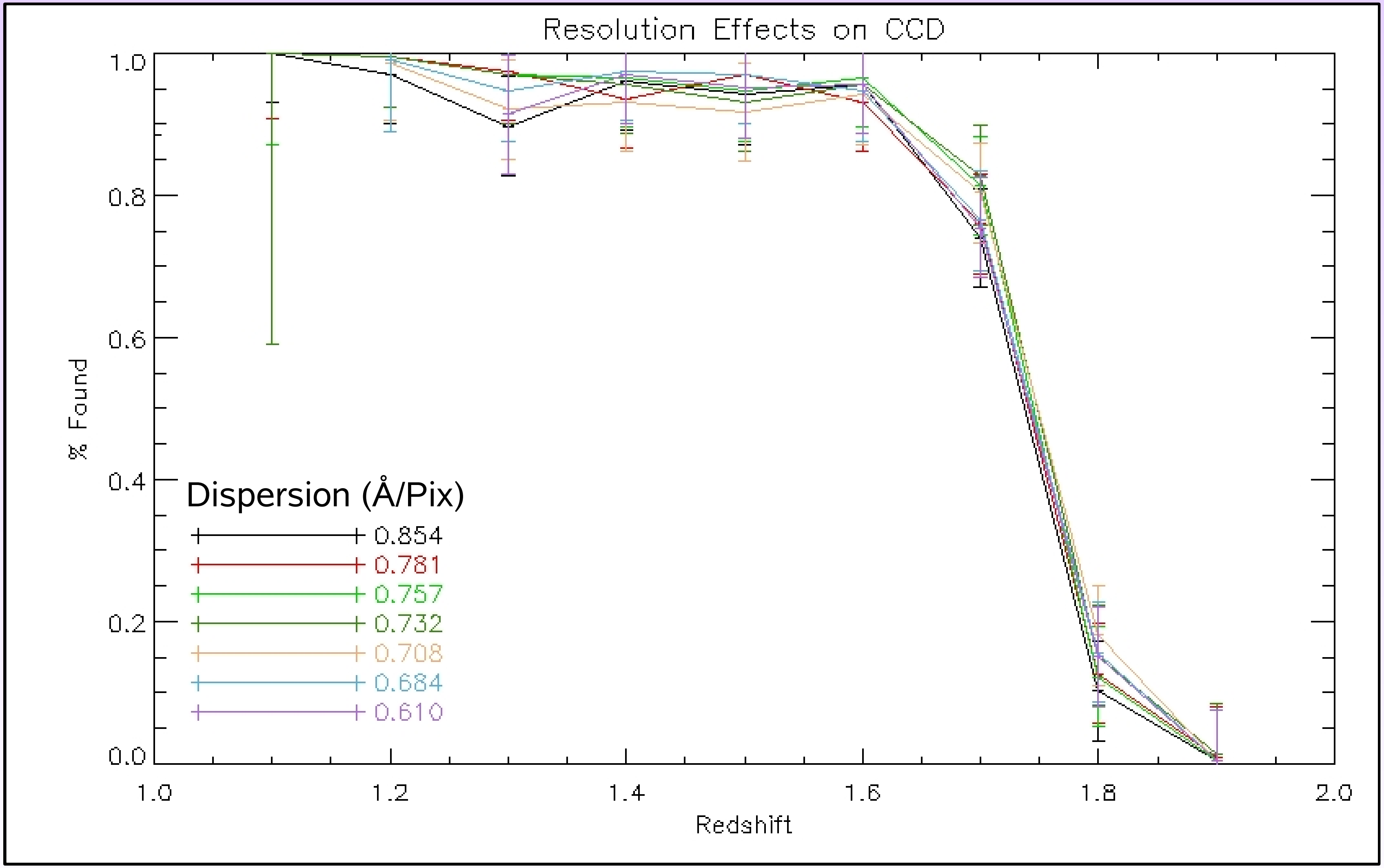


Simulation Results: Resolution Effects

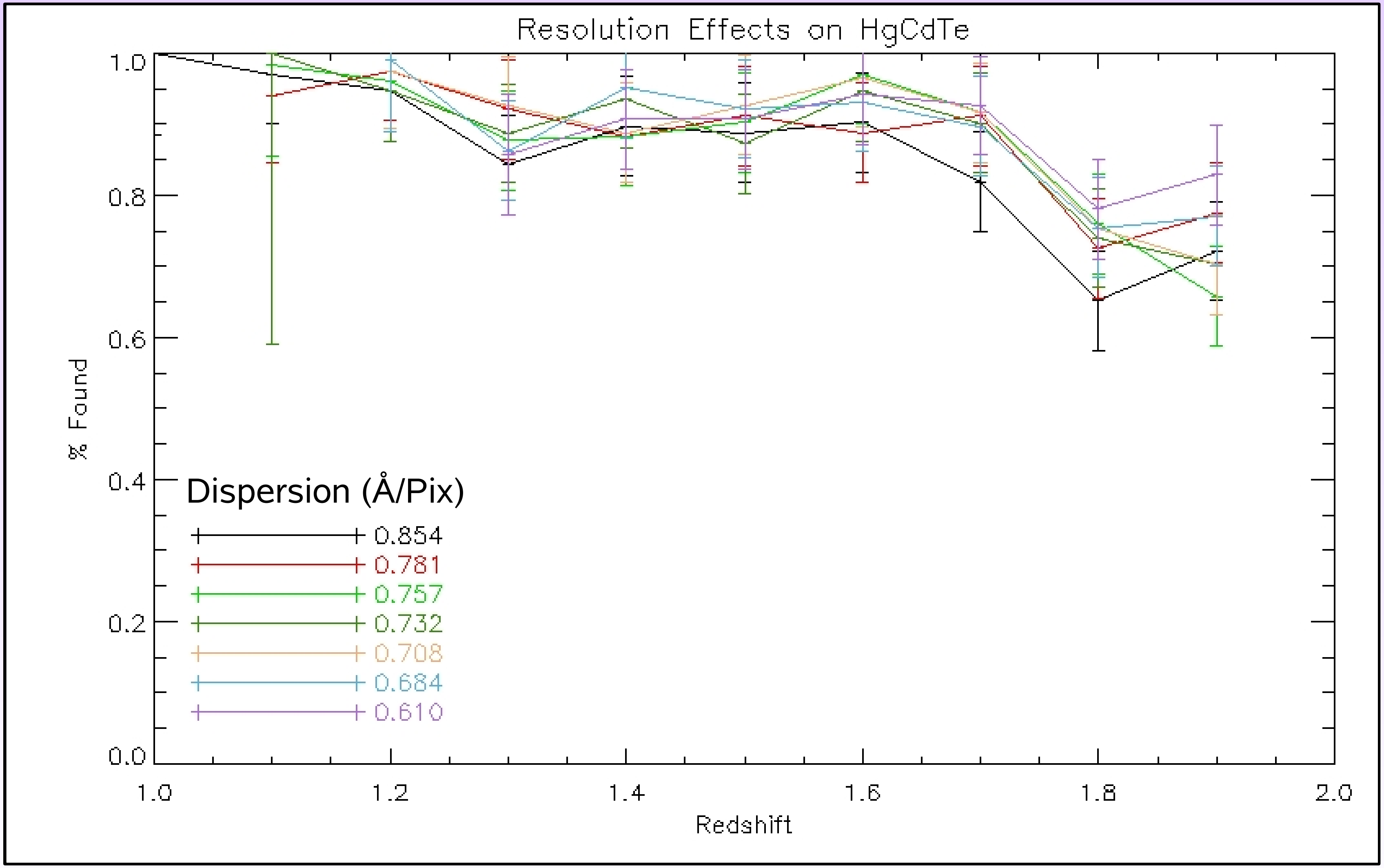
Resolution Effects

- What effect does resolution have in redshift-finding success rate?
- Simulate spectra of various resolutions at MDLF
  - Number of pixels kept constant → wavelength coverage differs between simulations
- Focus on OII doublet

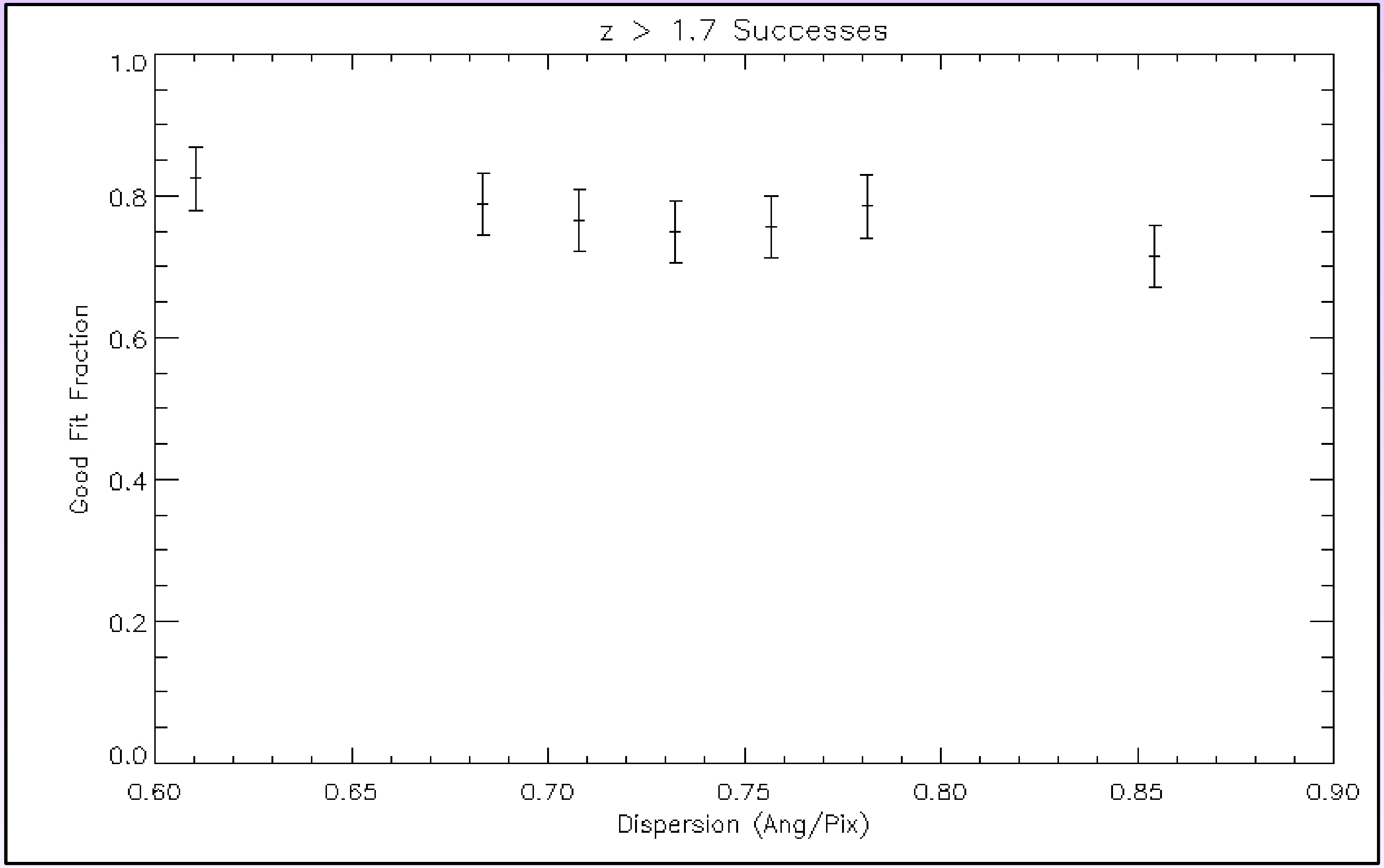
CCD Results


Resolution Effects on CCD
% Found
Redshift
1.0
0.8
0.6
0.4
0.2
0.0
1.0
1.2
1.4
1.6
1.8
2.0
Dispersion (Å/Pix)
0.854
0.781
0.757
0.732
0.708
0.684
0.610

HgCdTe Results



HgCdTe High-z Close Up



- Success appears to be a weak function of dispersion
- Initial spectrum simulation resolution may be limiting effectiveness of high resolution templates

Possible Improvements

- Lots of information in spectra not utilized
  - Continuum emission
  - PCA coefficients / line fluxes
    - negative coefficient → fit to noise
    - unreasonably bright lines at high z → misfit
  - Doublet shape
  - Second best fit
    - True z should have *significantly* smaller χ^2 than second best fit
- Additional spectroscopic coverage to ensure OII detection

Conclusions

- OII doublet is a sensitive tool for detecting emission line galaxy redshifts at $z > 1.0$
- For reasonable assumptions about line fluxes, success rates are ≥ 90%
- Success rates are a weak function of spectrograph resolution
- Higher success rates certainly possible with more sophisticated code!